INVESTIGATING THE MINERAL:MICROBE CONTINUUM IN LAVA CAVES TO ENHANCE SELECTION OF LIFE DETECTION TARGETS. D. E. Northup[1], J. J. M. Hathaway[1], M. N. Spilde[2], D. P. Moser[3], and J. G. Blank[4, 5], [1]Biology Department, University of New Mexico, dnorthup@unm.edu, [2]Institute of Meteoritics, University of New Mexico, mspilde@unm.edu, [3]Division of Hydrologic Sciences, Desert Research Institute, Duane.Moser@dri.edu, [4]Division of Space Sciences & Astrobiology, NASA Ames Research Center, [5]Blue Marble Space Institute of Science, jen@bmsis.org

Introduction: Earth's caves have provided valuable analogues for exploring best targets for life detection on extraterrestrial bodies [1, 2]. Microorganisms in Earth's lava caves create a variety of visible features visible that range from secondary mineral deposits to microbial mats that line cave surfaces. We hypothesized that secondary mineral shape, texture, vertical heterogeneity, and color would be predictive of the extent of potential microbial content and microbial diversity. Our goal was to see if these features form a continuum from very mineral to microbial in appearance, which could be used to inform best targets for robotic missions. To characterize this proposed continuum, we investigated the bacterial and archaeal diversity a variety of features in Lava Beds National Monument (LABE, northern California, USA) in 2017–2018 as part of BRAILLE (Biologic and Resource Analog Investigations in Low Light Environments), a research project sponsored by NASA's Planetary Science and Technology in Analog Research program. Among BRAILLE's objectives is the characterizing of mineral biosignatures in lava caves, in order to enhance remote capabilities for detection of life (past or present) on extraterrestrial bodies, such as Mars, where lava caves have been detected. Our work aims to determine the degree to which lava cave secondary mineral deposits contain microorganisms in order to enhance future robotic life detection strategies. Samples were collected aseptically from several lava caves in LABE, distinct in age, lava flows, cave geometry, and human visitation. Secondary mineral samples were selected that included a variety of textures and shapes such as polyps, round knobs, corraloids, cauliflower-like structures, and ooze-like biofilms. Microbial mat samples that were, white, tan, or yellow in color were also sampled.

Scanning electron microscopy (SEM) revealed several common potential microbial forms, including fuzzy and smooth filaments, rods, spheroids, and beads-on-a-string structures. Energy-dispersive X-ray spectroscopy (EDX) revealed that silica-rich films covered extensive portions of most of the samples examined. Some calcite deposits were also detected. Secondary mineral deposits contained a higher abundance of smooth filaments, fewer instances of microbial colonies, and less microbial morphologies overall. Microbial mats, on the other hand, exhibited extensive microbial morphologies, with a greater proportion of fuzzy rods, fuzzy filaments, and beads-on-a-string shapes, with some variation across differently colored mats.

Microbial community structure was characterized on the Illumina platform using domain-specific primer sets targeting Bacteria and Archaea, which included the bacterial primer 515F, and the archaeal specific primer 519F. Both mineral and microbial mat samples exhibited extensive microbial diversity, but 10X DNA was recovered from microbial mat samples in comparison to the most mineral samples. Composition at the bacterial phylum level showed some variation across mineral and mat samples. Actinobacteria, a dominant cave bacterial phylum, was present at moderate abundance across mat samples and some mineral samples. One bacterial phylum in particular, Nitrospirae, was more abundant in microbial mat samples than in secondary mineral samples, however. Nonmetric dimensional scaling (NMDS) plots of diversity dissimilarities of both archaeal and bacteria sequences revealed that mat samples are more similar to each other than mineral samples are to each other, and are very dissimilar to mineral samples. Our results suggest that a variety of mineral deposits are worth investigating as potential targets for life detection in Earth and extraterrestrial caves. Understanding which mineral textures, shapes, color and compositions are most predictive of the presence and extent of microbial life will enhance future robotic life detection strategies.

References: [1] Boston P. J. et al. (2001) *Astrobiology Journal, 1,* 25-55. [2] Northup D.E. (2011) *Astrobiology, 11*, 601-618.